## Low Noise, Low Power, SPI® Bus, 128 Taps, Wiper Only

The ISL22449 integrates four digitally controlled potentiometers (DCP) and non-volatile memory on a monolithic CMOS integrated circuit.

The digitally controlled potentiometers are implemented with a combination of resistor elements and CMOS switches. The position of the wipers are controlled by the user through the SPI serial interface. Each potentiometer has an associated volatile Wiper Register (WR) and a non-volatile Initial Value Register (IVR) that can be directly written to and read by the user. The contents of the WR controls the position of the wiper. At power-up the device recalls the contents of the DCP's IVR to the corresponding WR.

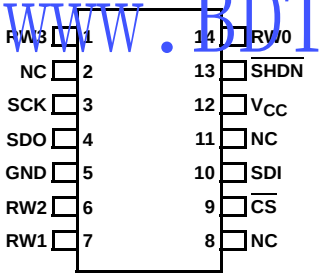
The DCP can be used as a voltage divider in a wide variety of applications including control, parameter adjustments, AC measurement and signal processing.

## Features

- Four potentiometers in one package
- 128 resistor taps
- SPI serial interface
- Non-volatile storage of wiper position
- Wiper resistance: 70Ω typical
- Shutdown mode
- Shutdown current 6.5µA max
- Power supply: 2.7V to 5.5V
- 50kΩ or 10kΩ total resistance
- High reliability
  - Endurance: 1,000,000 data changes per bit per register
  - Register data retention: 50 years @ T ≤ +55°C
- 14 Lead TSSOP
- Pb-free plus anneal product (RoHS compliant)

## Pinout

**ISL22449**
**(14 LD TSSOP)**
TOP VIEW

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## Ordering Information

| PART NUMBER | PART MARKING | RESISTANCE OPTION (kΩ) | TEMP. RANGE (°C) | PACKAGE | PKG. DWG. # |
|---|---|---|---|---|---|
| ISL22449UFV14Z (Notes 1, 2) | 22449 UFVZ | 50 | -40 to +125 | 14 Ld TSSOP (Pb-free) | M14.173 |
| ISL22449WFV14Z (Notes 1, 2) | 22449 WFVZ | 10 | -40 to +125 | 14 Ld TSSOP (Pb-free) | M14.173 |

NOTES:

1. Intersil Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.
2. Add "-TK" suffix for 1,000 Tape and Reel option



CAUTION: These devices are sensitive to electrostatic discharge; follow proper IC Handling Procedures.
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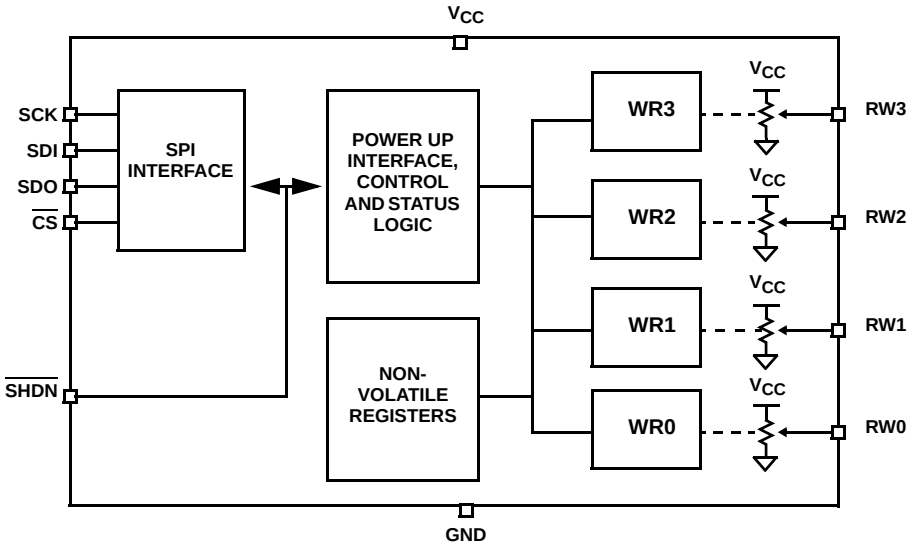
## Block Diagram




## Pin Descriptions

| TSSOP PIN | SYMBOL | DESCRIPTION |
|---|---|---|
| 1 | RW3 | “Wiper” terminal of DCP3 |
| 2 | NC | |
| 3 | SCK | SPI clock input |
| 4 | SDO | SPI open drain data output |
| 5 | GND | Device ground pin and the RL connection for each DCP |
| 6 | RW2 | “Wiper” terminal of DCP2 |
| 7 | RW1 | “Wiper” terminal of DCP1 |
| 8 | NC | |
| 9 | $\overline{CS}$ | SPI Chip Select active low input |
| 10 | SDI | SPI data input |
| 11 | NC | |
| 12 | VCC | Power supply pin and the RH connection for each DCP |
| 13 | $\overline{SHDN}$ | Shutdown active low input |
| 14 | RW0 | “Wiper” terminal of DCP0 |

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## Absolute Maximum Ratings

Storage Temperature . . . . . -65°C to +150°C
Voltage at any Digital Interface Pin
with Respect to GND . . . . . -0.3V to $V_{CC}$+0.3
$V_{CC}$ . . . . . -0.3V to +6V
Voltage at any DCP pin with Respect to GND . . . . . -0.3V to $V_{CC}$
Lead Temperature (Soldering, 10s) . . . . . +300°C
$I_W$ (10s) . . . . . ±6mA
Latchup (Note 4) . . . . . Class II, Level B @ +125°C
ESD (HBM) . . . . . 2.5kV
(CDM) . . . . . 1kV

## Thermal Information

| Thermal Resistance (Typical, Note 3) | $\theta_{JA}$ (°C/W) |
|---|---|
| 14 Ld TSSOP | +100 |

Maximum Junction Temperature (Plastic Package) . . . . . +150°C

## Recommended Operating Conditions

Ambient Temperature . . . . . -40°C to +125°C
$V_{CC}$ Voltage for DCP Operation . . . . . 2.7V to 5.5V
Wiper Current . . . . . -3mA to 3mA
Power Rating . . . . . 5mW

*CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

NOTES:

3. $\theta_{JA}$ is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
4. Jedec Class II pulse conditions and failure criterion used. Level B exceptions are: using a max positive pulse of 6.5V on the SHDN pin, and using a max negative pulse of -0.8V for all pins.

## Analog Specifications

Over recommended operating conditions unless otherwise stated.

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP (NOTE 5) | MAX | UNIT |
|---|---|---|---|---|---|---|
| $R_{TOTAL}$ | End-to-End resistance | W option | | 10 | | kΩ |
| | | U option | | 50 | | kΩ |
| | End-to-End resistance tolerance | W and U option | -20 | | +20 | % |
| | End-to-End Temperature Coefficient | W option | | ±50 | | ppm/°C (Note 15) |
| | | U option | | ±80 | | ppm/°C (Note 15) |
| $R_W$ | Wiper resistance | $V_{CC}$ = 3.3V @ +25°C, wiper current = $V_{CC}/R_{TOTAL}$ | | 70 | 200 | Ω |
| $C_W$ (Note 15) | Wiper capacitance | | | 25 | | pF |
| **VOLTAGE DIVIDER MODE** (measured at $R_W$i, unloaded; i = 0, 1, 2 or 3) | | | | | | |
| INL (Note 10) | Integral non-linearity | | -1 | | 1 | LSB (Note 6) |
| DNL (Note 9) | Differential non-linearity | Monotonic over all tap positions | -0.5 | | 0.5 | LSB (Note 6) |
| ZSerror (Note 7) | Zero-scale error | W option | 0 | 1 | 5 | LSB (Note 6) |
| | | U option | 0 | 0.5 | 2 | |
| FSerror (Note 8) | Full-scale error | W option | -5 | -1 | 0 | LSB (Note 6) |
| | | U option | -2 | -1 | 0 | |
| $V_{MATCH}$ (Note 11) | DCP to DCP matching | Any two DCPs at same tap position | -2 | | 2 | LSB (Note 6) |
| $TC_V$ (Note 12) | Ratiometric temperature coefficient | DCP register set to 40 hex | | ±4 | | ppm/°C |

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## Operating Specifications

Over the recommended operating conditions unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP (NOTE 5) | MAX | UNIT |
|---|---|---|---|---|---|---|
| $I_{CC1}$ | $V_{CC}$ Supply Current (volatile write/read) | $V_{CC}$ = +3.6V, 10k DCP, $f_{SPI}$ = 5MHz; (for SPI active, read and write states) | | | 2.5 | mA |
| | $V_{CC}$ Supply Current (volatile write/read) | $V_{CC}$ = +3.6V, 50k DCP, $f_{SPI}$ = 5MHz; (for SPI active, read and write states) | | | 0.65 | mA |
| $I_{CC2}$ | $V_{CC}$ Supply Current ( non-volatile write/read) | $V_{CC}$ = +5.5V, 10k DCP, $f_{SPI}$ = 5MHz; (for SPI active, read and write states) | | | 4.0 | mA |
| | $V_{CC}$ Supply Current ( non-volatile write/read) | $V_{CC}$ = +5.5V, 50k DCP, $f_{SPI}$ = 5MHz; (for SPI active, read and write states) | | | 3.0 | mA |
| $I_{SB}$ | $V_{CC}$ Current (standby) | $V_{CC}$ = +5.5V, 10k DCP, SPI interface in standby state | | | 2.4 | mA |
| | | $V_{CC}$ = +5.5V, 50k DCP, SPI interface in standby state | | | 525 | µA |
| | | $V_{CC}$ = +3.6V, 10k DCP, SPI interface in standby state | | | 1.6 | mA |
| | | $V_{CC}$ = +3.6V, 50k DCP, SPI interface in standby state | | | 350 | µA |
| $I_{SD}$ | $V_{CC}$ Current (shutdown) | $V_{CC}$ = +5.5V @ +85°C, SPI interface in standby state | | | 5 | µA |
| | | $V_{CC}$ = +5.5V@ +125°C, SPI interface in standby state | | | 6.5 | µA |
| | | $V_{CC}$ = +3.6V @ +85°C, SPI interface in standby state | | | 4 | µA |
| | | $V_{CC}$ = +3.6V @ +125°C, SPI interface in standby state | | | 5.5 | µA |
| $I_{LkgDig}$ | Leakage current, at pins $\overline{SHDN}$, SCK, SDI, SDO and $\overline{CS}$ | Voltage at pin from GND to $V_{CC}$ | -1 | | 1 | µA |
| $t_{WRT}$ (Note 15) | DCP wiper response time | SCK falling edge of last bit of DCP data byte to wiper new position | | 1.5 | | µs |
| $t_{ShdnRec}$ (Note 15) | DCP recall time from shutdown mode | From rising edge of $\overline{SHDN}$ signal to wiper stored position and RH connection | | 1.5 | | µs |
| | | SCK rising edge of last bit of ACR data byte to wiper stored position and RH connection | | 1.5 | | µs |
| Vpor | Power-on recall voltage | Minimum $V_{CC}$ at which memory recall occurs | 2.0 | | 2.6 | V |
| VccRamp | Vcc ramp rate | | 0.2 | | | V/ms |
| $t_D$ | Power-up delay | $V_{CC}$ above Vpor, to DCP Initial Value Register recall completed, and SPI Interface in standby state | | | 3 | ms |
| **EEPROM SPECIFICATION** | | | | | | |
| | EEPROM Endurance | | 1,000,000 | | | Cycles |
| | EEPROM Retention | Temperature T ≤ +55°C | 50 | | | Years |
| $t_{WC}$ (Note 13) | Non-volatile Write cycle time | | | 12 | 20 | ms |
| **SERIAL INTERFACE SPECIFICATIONS** | | | | | | |
| $V_{IL}$ | $\overline{SHDN}$, SCK, SDI, and $\overline{CS}$ input buffer LOW voltage | | -0.3 | | 0.3*$V_{CC}$ | V |
| $V_{IH}$ | $\overline{SHDN}$, SCK, SDI, and $\overline{CS}$ input buffer HIGH voltage | | 0.7*$V_{CC}$ | | $V_{CC}$+0.3 | V |

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**Operating Specifications** Over the recommended operating conditions unless otherwise specified. **(Continued)**

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP (NOTE 5) | MAX | UNIT |
|---|---|---|---|---|---|---|
| Hysteresis | $\overline{SHDN}$, SCK, SDI, and $\overline{CS}$ input buffer hysteresis | | 0.05* $V_{CC}$ | | | V |
| $V_{OL}$ | SDO output buffer LOW voltage | $I_{OL}$ = 4mA | 0 | | 0.4 | V |
| $R_{pu}$ (Note 14) | SDO pull-up resistor off-chip | Maximum is determined by $t_{RO}$ and $t_{FO}$ with maximum bus load Cbus = 30pF, $f_{SCK}$ = 5MHz | | | 2 | kΩ |
| Cpin (Note 15) | $\overline{SHDN}$, SCK, SDI, SDO and $\overline{CS}$ pin capacitance | | | | 10 | pF |
| $f_{SCK}$ | SPI frequency | | | | 5 | MHz |
| $t_{CYC}$ | SPI clock cycle time | | 200 | | | ns |
| $t_{WH}$ | SPI clock high time | | 100 | | | ns |
| $t_{WL}$ | SPI clock low time | | 100 | | | ns |
| $t_{LEAD}$ | Lead time | | 250 | | | ns |
| $t_{LAG}$ | Lag time | | 250 | | | ns |
| $t_{SU}$ | SDI, SCK and $\overline{CS}$ input setup time | | 50 | | | ns |
| $t_H$ | SDI, SCK and $\overline{CS}$ input hold time | | 50 | | | ns |
| $t_{RI}$ | SDI, SCK and $\overline{CS}$ input rise time | | 10 | | | ns |
| $t_{FI}$ | SDI, SCK and $\overline{CS}$ input fall time | | 10 | | 20 | ns |
| $t_{DIS}$ | SDO output Disable time | | 0 | | 100 | ns |
| $t_V$ | SDO output valid time | | | | 350 | ns |
| $t_{HO}$ | SDO output hold time | | 0 | | | ns |
| $t_{RO}$ | SDO output rise time | $R_{pu}$ = 2k, Cbus = 30pF | | | 60 | ns |
| $t_{FO}$ | SDO output fall time | $R_{pu}$ = 2k, Cbus = 30pF | | | 60 | ns |
| $t_{CS}$ | CS deselect time | | 2 | | | µs |
| $t_{WRT}$ | Wiper Response Time after SPI write to WR register | | | | 1.5 | µs |

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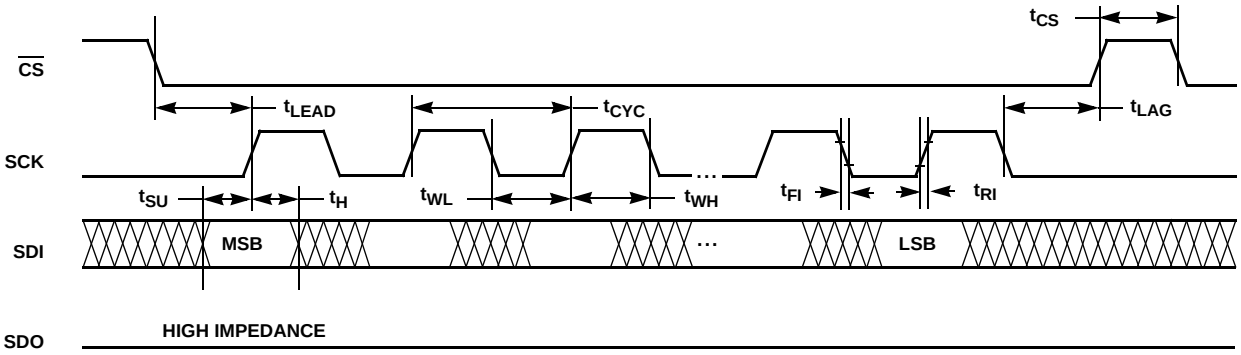
NOTES:

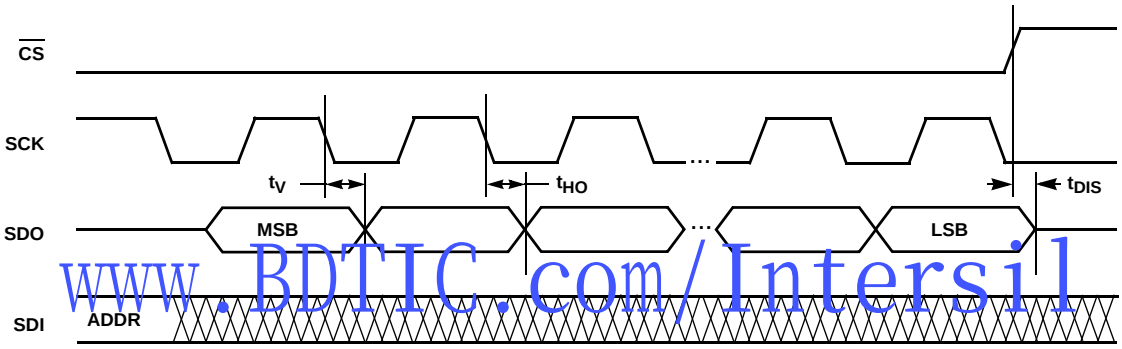
5. Typical values are for $T_A$ = +25°C and 3.3V supply voltage.
6. LSB: $[V(R_W)_{127} – V(R_W)_0]/127$. $V(R_W)_{127}$ and $V(R_W)_0$ are $V(R_W)$ for the DCP register set to 7F hex and 00 hex respectively. LSB is the incremental voltage when changing from one tap to an adjacent tap.
7. ZS error = $V(RW)_0$/LSB.
8. FS error = $[V(RW)_{127} – V_{CC}]$/LSB.
9. DNL = $[V(RW)_i – V(RW)_{i-1}]$/LSB-1, for i = 1 to 127. i is the DCP register setting.
10. INL = $[V(RW)_i – i • LSB – V(RW)]$/LSB for i = 1 to 127
11. $V_{MATCH}$ = $[V(RWx)_i – V(RWy)_i]$/LSB, for i = 1 to 127, x = 0 to 3 and y = 0 to 3.
12. $TC_V = \frac{Max(V(RW)_i) - Min(V(RW)_i)}{[Max(V(RW)_i) + Min(V(RW)_i)]/2} \times \frac{10^6}{165°C}$ for i = 16 to 112 decimal, T = -40°C to +125°C. Max( ) is the maximum value of the wiper voltage and Min ( ) is the minimum value of the wiper voltage over the temperature range.
13. $t_{WC}$ is the time from the end of a Write sequence of SPI serial interface, to the end of the self-timed internal non-volatile write cycle.
14. $R_{pu}$ is specified for the highest data rate transfer for the device. Higher value pullup can be used at lower data rates.
15. This parameter is not 100% tested.

## Timing Diagrams

### Input Timing




### Output Timing

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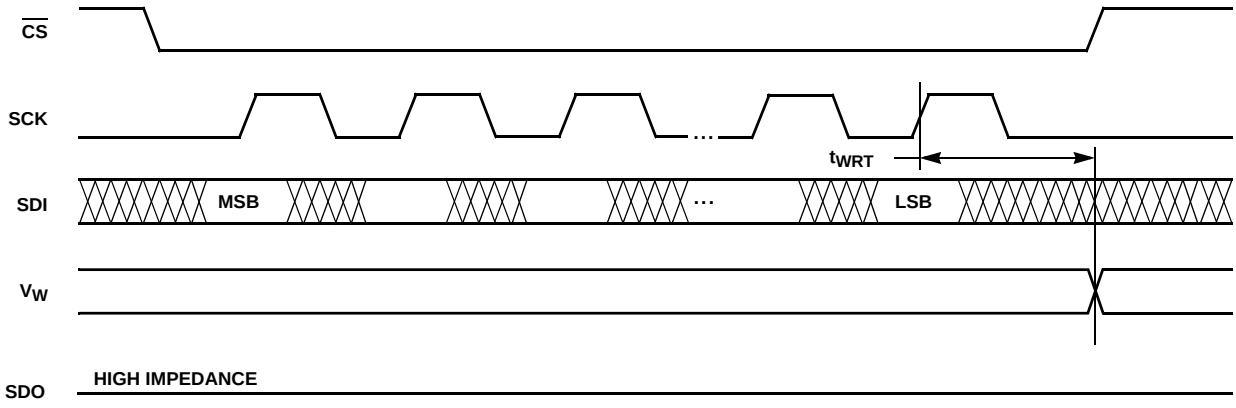
### XDCP Timing (for All Load Instructions)



## Typical Performance Curves

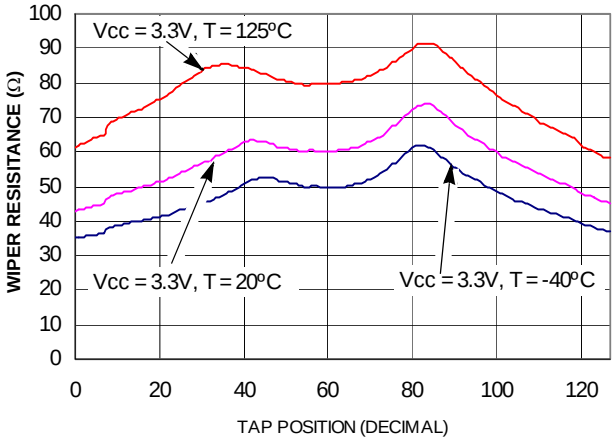



FIGURE 1. WIPER RESISTANCE vs TAP POSITION [I(RW) = $V_{CC}/R_{TOTAL}$] FOR 10kΩ (W)

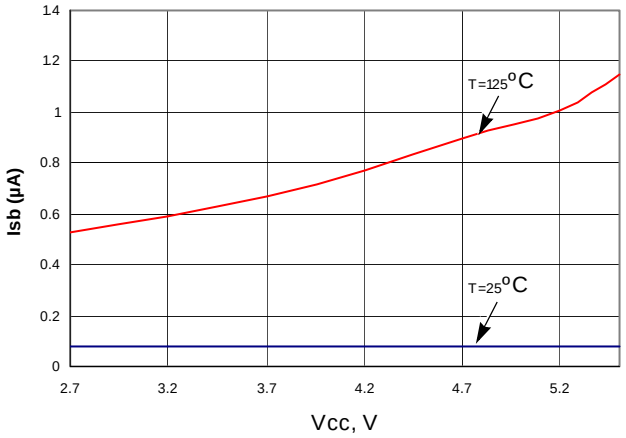



FIGURE 2. STANDBY $I_{CC}$ vs $V_{CC}$

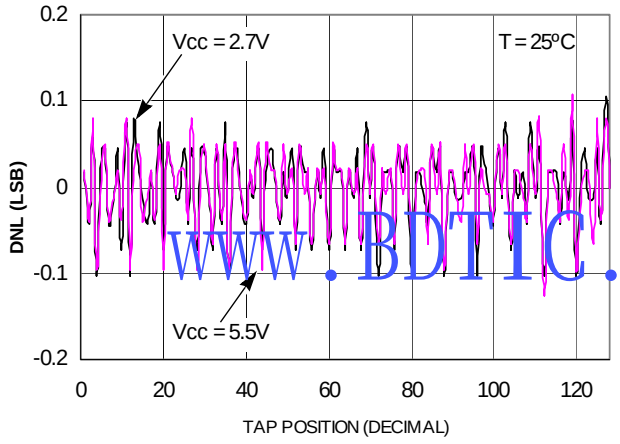



FIGURE 3. DNL vs TAP POSITION IN VOLTAGE DIVIDER MODE FOR 10kΩ (W)

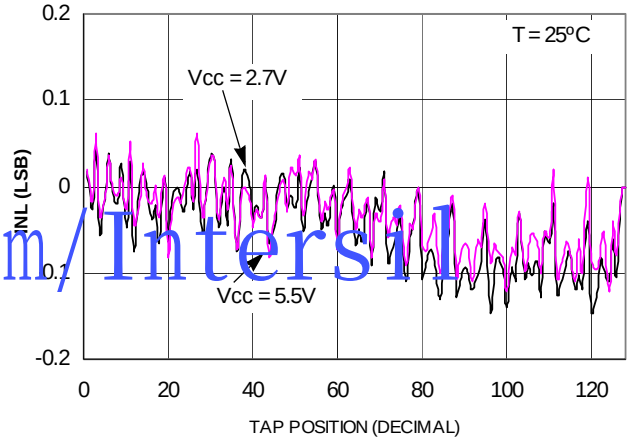



FIGURE 4. INL vs TAP POSITION IN VOLTAGE DIVIDER MODE FOR 10kΩ (W)

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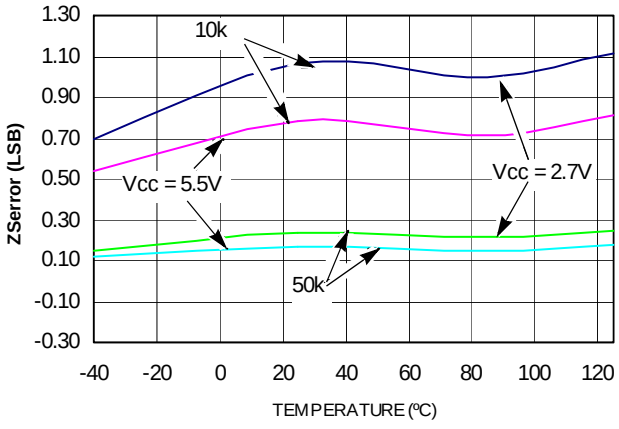


FIGURE 5. ZSerror vs TEMPERATURE

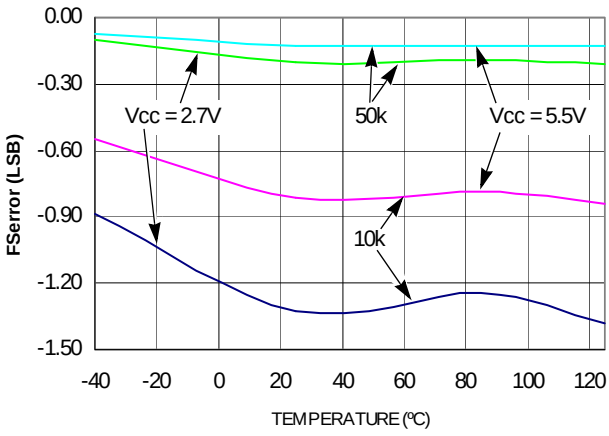


FIGURE 6. FSerror vs TEMPERATURE

## Typical Performance Curves (Continued)

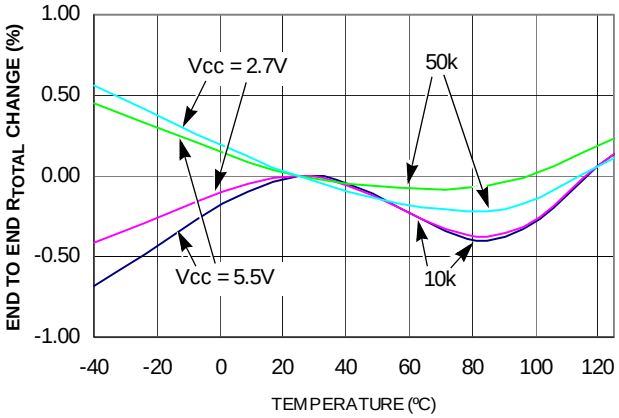


FIGURE 7. END TO END $R_{TOTAL}$ % CHANGE vs TEMPERATURE

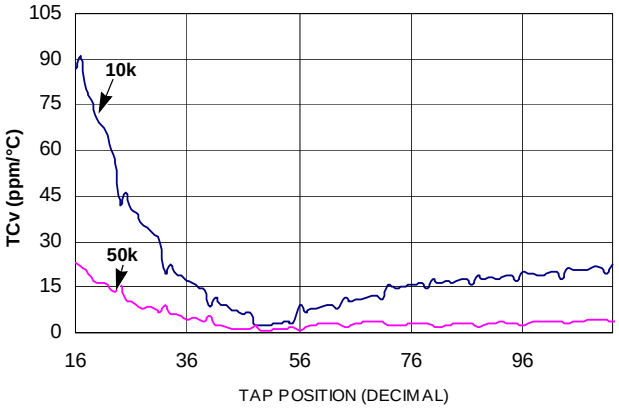


FIGURE 8. TC FOR VOLTAGE DIVIDER MODE IN ppm

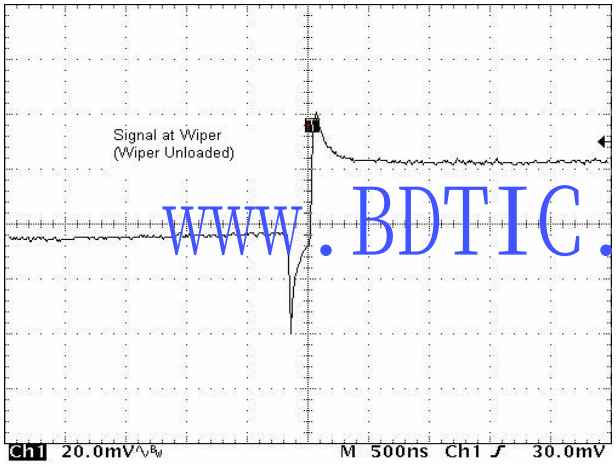


FIGURE 9. MIDSCALE GLITCH, CODE 80h TO 7Fh

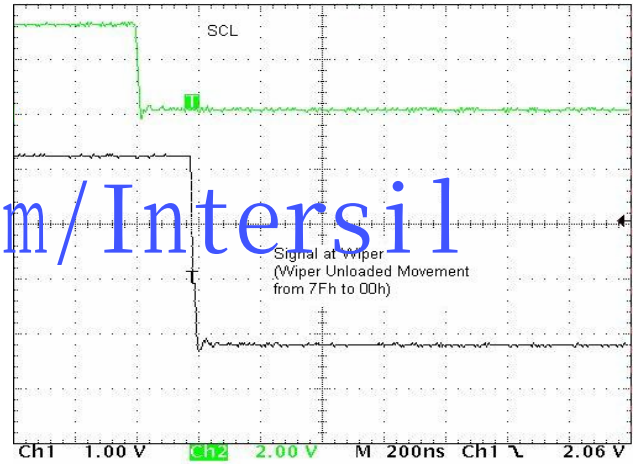


FIGURE 10. LARGE SIGNAL SETTLING TIME

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## Pin Description

### Potentiometers Pins

**RWi (i = 0, 1, 2, 3)**

RWi is the wiper terminal and is equivalent to the movable terminal of a mechanical potentiometer. The position of the wiper within the array is determined by the WRi register.

**$\overline{SHDN}$**

The $\overline{SHDN}$ pin forces the resistors to end-to-end open circuit condition and shorts all RWs to GND. When $\overline{SHDN}$ is returned to logic high, the previous latch settings put RWi at the same resistance setting prior to shutdown. This pin is logically OR'd with SHDN bit in ACR register. SPI interface is still available in shutdown mode and all registers are accessible. This pin must remain HIGH for normal operation.

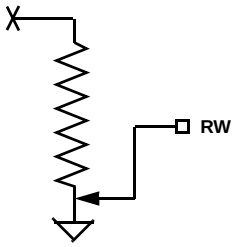


FIGURE 11. DCP CONNECTION IN SHUTDOWN MODE

### Bus Interface Pins

**Serial Clock (SCK)**

This is the serial clock input of the SPI serial interface.

**Serial Data Output (SDO)**

The SDO is an open drain serial data output pin. During a read cycle, the data bits are shifted out at the falling edge of the serial clock SCK, while the $\overline{CS}$ input is low.

SDO requires an external pull-up resistor for proper operation.

**Serial Data Input (SDI)**

The SDI is the serial data input pin for the SPI interface. It receives device address, operation code, wiper address and data from the SPI external host device. The data bits are shifted in at the rising edge of the serial clock SCK, while the $\overline{CS}$ input is low.

**Chip Select ($\overline{CS}$)**

$\overline{CS}$ LOW enables the ISL22449, placing it in the active power mode. A HIGH to LOW transition on $\overline{CS}$ is required prior to the start of any operation after power up. When $\overline{CS}$ is HIGH, the ISL22449 is deselected and the SDO pin is at high impedance, and (unless an internal write cycle is underway) the device will be in the standby state.

## Principles of Operation

The ISL22449 is an integrated circuit incorporating four DCPs with its associated registers, non-volatile memory and the SPI serial interface providing direct communication between host and potentiometers and memory. The resistor array is comprised of individual resistors connected in series. At either end of the array and between each resistor is an electronic switch that transfers the potential at that point to the wiper.

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The electronic switches on the device operate in a “make before break” mode when the wiper changes tap positions.

When the device is powered down, the last value stored in IVRi will be maintained in the non-volatile memory. When power is restored, the contents of the IVRi is recalled and loaded into the corresponding WRi to set the wiper to the initial value.

### DCP Description

Each DCP is implemented with a combination of resistor elements and CMOS switches. The physical ends of each DCP are equivalent to the fixed terminals of a mechanical potentiometer and internally connected to Vcc and GND. The RW pin of each DCP is connected to intermediate nodes, and is equivalent to the wiper terminal of a mechanical potentiometer. The position of the wiper terminal within the DCP is controlled by volatile Wiper Register (WR). Each DCP has its own WR. When the WR of a DCP contains all zeroes (WR[6:0]= 00h), its wiper terminal (RW) is closest to GND. When the WR register of a DCP contains all ones (WR[6:0]= 7Fh), its wiper terminal (RW) is closest to $V_{CC}$. As the value of the WR increases from all zeroes (0) to all ones (127 decimal), the wiper moves monotonically from the position closest to GND to the closest to $V_{CC}$.

While the ISL22449 is being powered up, all four WRs are reset to 40h (64 decimal), which locates RW roughly at the center between GND and $V_{CC}$. After the power supply voltage becomes large enough for reliable non-volatile memory reading, all WRs will be reload with the value stored in corresponding non-volatile Initial Value Registers (IVRs).

The SPI interface register address bits have to be set to 0000b, 0001b, 0010b or 0011b to access the WR of DCP0, DCP1, DCP2 or DCP3 respectively. The WRi and IVRi can be read or written to directly using the SPI serial interface as described in the following sections.

### Memory Description

The ISL22449 contains seven non-volatile and five volatile 8-bit registers. The memory map of ISL22449 is on Table 1. The four non-volatile registers (IVRi) at address 0, 1, 2 and 3, contain initial wiper value and volatile registers (WRi) contain current wiper position. In addition, three non-volatile General Purpose registers from address 4 to address 6 are available.

**TABLE 1. MEMORY MAP**

| ADDRESS | NON-VOLATILE | VOLATILE |
|---|---|---|
| 8 | — | ACR |
| 7 | Reserved | |
| 6 | General Purpose | Not Available |
| 5 | General Purpose | Not Available |
| 4 | General Purpose | Not Available |
| 3 | IVR3 | WR3 |
| 2 | IVR2 | WR2 |
| 1 | IVR1 | WR1 |
| 0 | IVR0 | WR0 |

The non-volatile IVRi and volatile WRi registers are accessible with the same address.

The Access Control Register (ACR) contains information and control bits described below in Table 2.

The VOL bit (ACR[7]) determines whether the access is to wiper registers WR or initial value registers IVR.

**TABLE 2. ACCESS CONTROL REGISTER (ACR)**

| BIT # | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Bit Name | VOL | SHDN | WIP | 0 | 0 | 0 | 0 | 0 |

If VOL bit is 0, the non-volatile IVR register is accessible. If VOL bit is 1, only the volatile WRi is accessible. Note, value is written to IVRi register also is written to the WRi. The default value of this bit is 0.

The SHDN bit (ACR[6]) disables or enables Shutdown mode. This bit is logically OR’d with $\overline{SHDN}$ pin. When this bit is 0, DCPs are in Shutdown mode. Default value of SHDN bit is 1.

The WIP bit (ACR[5]) is read only bit. It indicates that non-volatile write operation is in progress. The WIP bit can be

read repeatedly after a non-volatile write to determine if the write has been completed. It is impossible to write to the IVRi, WRi or ACR while WIP bit is 1.

### SPI Serial Interface

The ISL22449 supports an SPI serial protocol, mode 0. The device is accessed via the SDI input and SDO output with data clocked in on the rising edge of SCK, and clocked out on the falling edge of SCK. $\overline{CS}$ must be LOW during communication with the ISL22449. SCK and $\overline{CS}$ lines are controlled by the host or master. The ISL22449 operates only as a slave device.

All communication over the SPI interface is conducted by sending the MSB of each byte of data first.

### Protocol Conventions

The first byte sent to the ISL22449 from the SPI host is the Identification Byte. A valid Identification Byte contains 0101 as the four MSBs, with the following four bits set to 0.

**TABLE 3. IDENTIFICATION BYTE FORMAT**

| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|
| (MSB) | | | | | | | (LSB) |

The next byte sent to the ISL22449 contains the instruction and register pointer information. The four MSBs are the instruction and four LSBs are register address (see Table 4).

**TABLE 4. IDENTIFICATION BYTE FORMAT**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| I3 | I2 | I1 | I0 | R3 | R2 | R1 | R0 |

There are only two valid instruction sets:

1011(binary) - is a Read operation

1100(binary) - is a Write operation

### Write Operation

A Write operation to the ISL22449 is a three-byte operation. It requires first, the $\overline{CS}$ transition from HIGH to LOW, then a valid Identification Byte, then a valid instruction byte following by Data Byte is sent to SDI pin. The host terminates the write operation by pulling the $\overline{CS}$ pin from LOW to HIGH. For a write to addresses 0000b to 0011b, the MSB at address 8 (ACR[7]) determines if the Data Byte is to be written to volatile or both volatile and non-volatile registers. Refer to “Memory Description” and Figure 12.

Device can receive more than one byte of data by auto incrementing the address after each received byte. Note after reaching the address 0110b, the internal pointer “rolls over” to address 0000b.

The internal non-volatile write cycle starts after rising edge of $\overline{CS}$ and takes up to 20ms. Thus, non-volatile registers must be written individually.

### Read Operation

A read operation to the ISL22449 is a three-byte operation. It requires first, the $\overline{CS}$ transition from HIGH to LOW, then a valid Identification Byte, then a valid instruction byte following by “dummy” Data Byte is sent to SDI pin. The SPI host reads the data from SDO pin on falling edge of SCK. The host terminates the read operation by pulling the $\overline{CS}$ pin from LOW to HIGH (see Figure 13).

The ISL22449 will provide the Data Bytes to the SDO pin as long as SCK is provided by the host from the registers indicated by an internal pointer. This pointer initial value is determined by the register address in the Read operation instruction, and increments by one during transmission of each Data Byte. After reaching the memory location 0110b, the pointer “rolls over” to 0000b, and the device continues to output the data for each received SCK clock.

In order to read back the non-volatile IVR, it is recommended that the application reads the ACR first to verify the WIP bit is 0. If the WIP bit (ACR[5]) is not 0, the host should repeat its reading sequence again.

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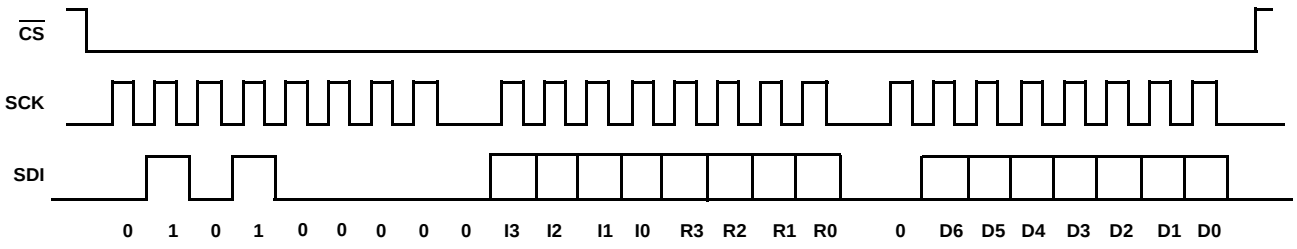


**FIGURE 12. THREE BYTE WRITE SEQUENCE**

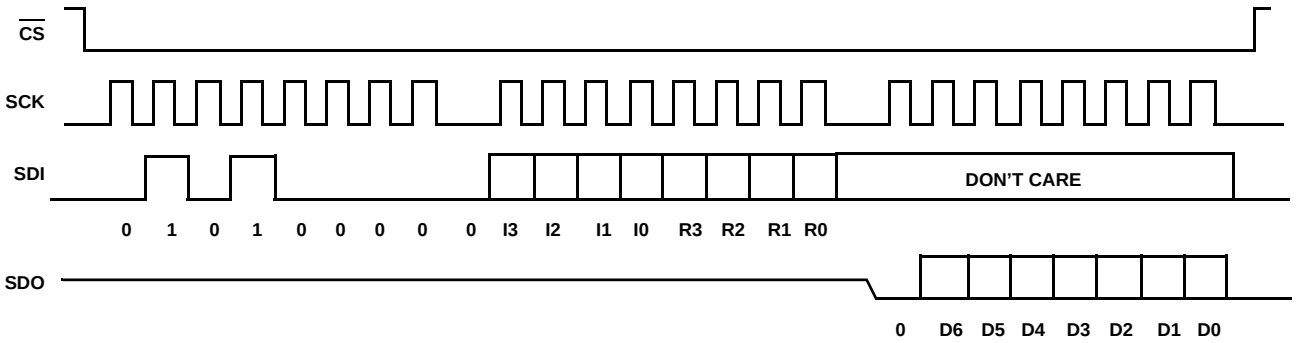


FIGURE 13. THREE BYTE READ SEQUENCE

## Applications Information

### Communicating with ISL22449

Communication with ISL22449 proceeds using SPI interface through the ACR (address 1000b), IVRi (addresses 0000b, 0001b, 0010b and 0011b) and WRi (addresses 0000b, 0001b, 0010b and 0011b) registers.

The wiper of the potentiometer is controlled by the WRi register. Writes and reads can be made directly to these registers to control and monitor the wiper position without any non-volatile memory changes. This is done by setting MSB bit at address 1000b to 1.

The non-volatile IVRi stores the power up value of the wiper. IVRs are accessible when MSB bit at address 1000b is set to 0. Writing a new value to the IVRi register will set a new power up position for the wiper. Also, writing to this register will load the same value into the corresponding WRi as the IVRi. Reading from the IVRi will not change the WRi, if its contents are different.

## Examples:

### A. Writing to the IVR:

This sequence will write a new value (77h) to the IVR2(non-volatile):

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Set the ACR (Addr 1000b) for NV write (40h)

Send the ID byte, Instruction Byte, then the Data byte

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

(Sent to SDI)

Set the IVR (Addr 0010b) to 77h

Send the ID byte, Instruction Byte, then the Data byte

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |

(Sent to SDI)

### B. Reading from the WR:

This sequence will read the value from the WR3 (volatile):

Write to ACR first to access the volatile WRs

Send the ID byte, Instruction Byte, then the Data byte

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

(Sent to SDI)

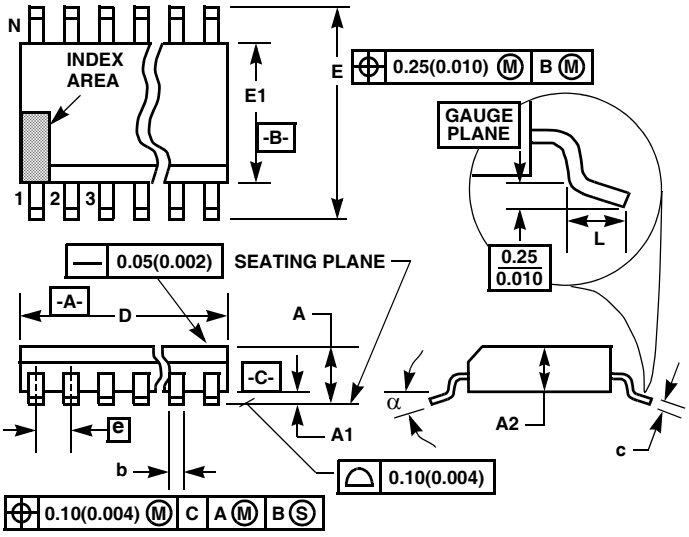
Read the data from WR3 (Addr 0011b)

Send the ID byte, Instruction Byte, then Read the Data byte

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | x | x | x | x | x | x | x | x |

(Out on SDO)

## Thin Shrink Small Outline Plastic Packages (TSSOP)




### M14.173

**14 LEAD THIN SHRINK SMALL OUTLINE PLASTIC PACKAGE**

| SYMBOL | INCHES | | MILLIMETERS | | NOTES |
|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | |
| A | - | 0.047 | - | 1.20 | - |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 | - |
| A2 | 0.031 | 0.041 | 0.80 | 1.05 | - |
| b | 0.0075 | 0.0118 | 0.19 | 0.30 | 9 |
| c | 0.0035 | 0.0079 | 0.09 | 0.20 | - |
| D | 0.195 | 0.199 | 4.95 | 5.05 | 3 |
| E1 | 0.169 | 0.177 | 4.30 | 4.50 | 4 |
| e | 0.026 BSC | | 0.65 BSC | | - |
| E | 0.246 | 0.256 | 6.25 | 6.50 | - |
| L | 0.0177 | 0.0295 | 0.45 | 0.75 | 6 |
| N | 14 | | 14 | | 7 |
| α | $0^o$ | $8^o$ | $0^o$ | $8^o$ | - |

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NOTES:

1. These package dimensions are within allowable dimensions of JEDEC MO-153-AC, Issue E.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension “E1” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.15mm (0.006 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. Dimension “b” does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm (0.003 inch) total in excess of “b” dimension at maximum material condition. Minimum space between protrusion and adjacent lead is 0.07mm (0.0027 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact. (Angles in degrees)

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